



GOODRICH

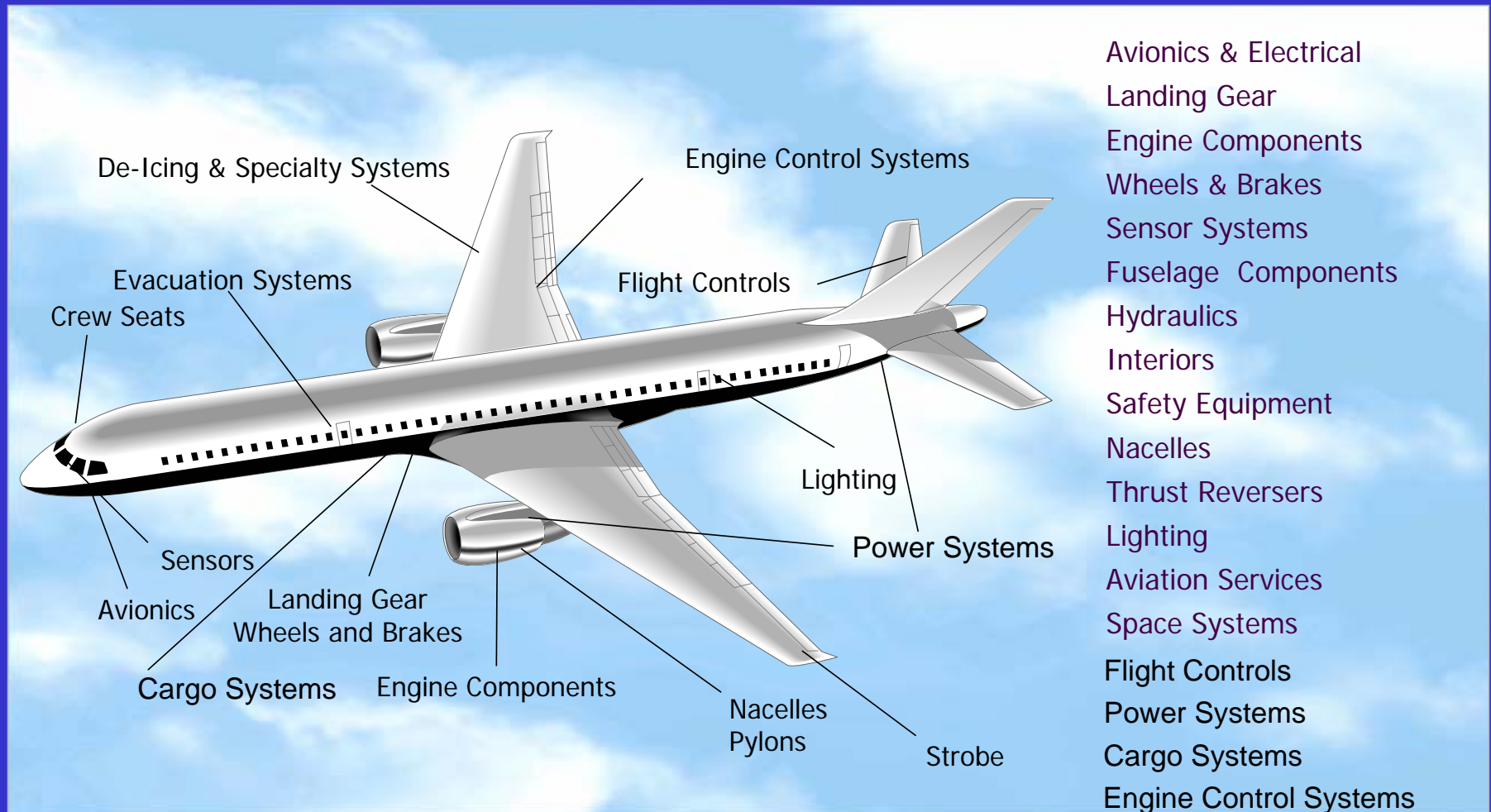
*Integrated Ice Protection
and
Self-Monitoring Rotor System*

presented to

*Wind Turbine Blade Workshop
Sandia National Laboratory*

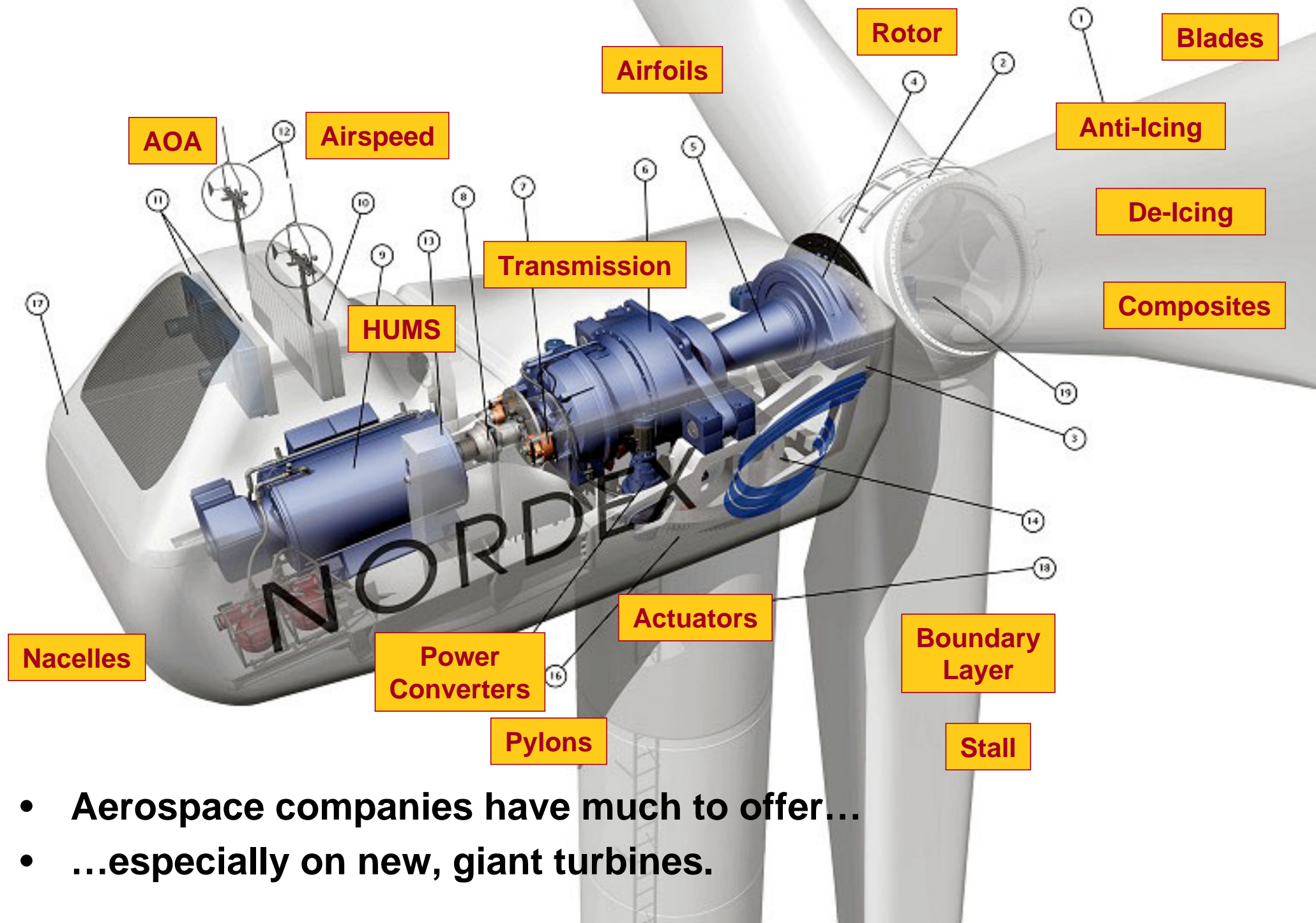
February 24-25, 2004

Global Leader With Multiple Proprietary Systems & Services



Goodrich Has an Extensive “Footprint”

Wind Turbine Terms are from Aerospace



- Aerospace companies have much to offer...
- ...especially on new, giant turbines.

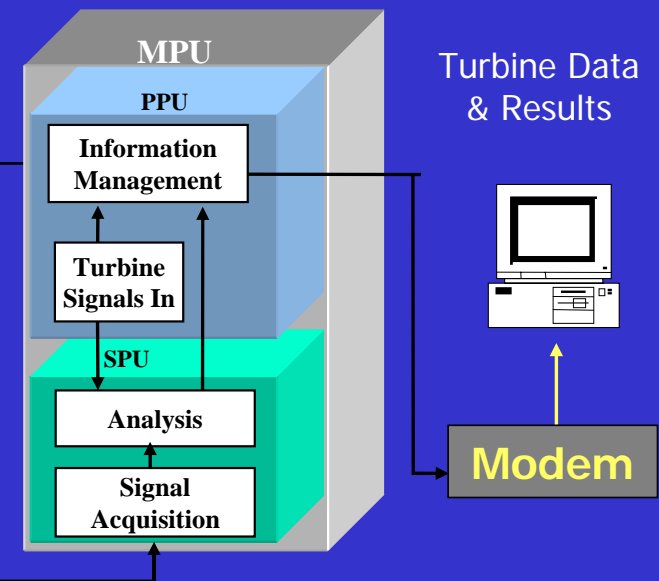
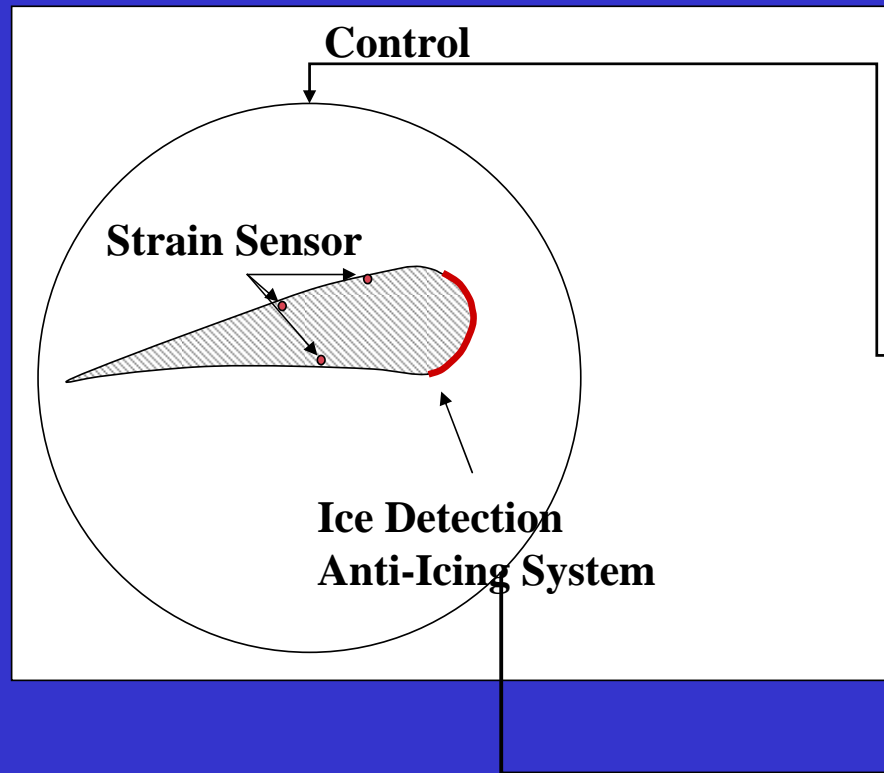
Fully Integrated Rotor System

RIMS:

- Remotely Interrogated Micro Sensors

Integrated Monitory System:

- Ice Sensing/Anti-Icing Control System
- HUMS: Health and Usage Monitory System
- Structural Health Monitoring
- Gear/Shaft/Bearing Monitoring



Turbine Integrated Monitory System

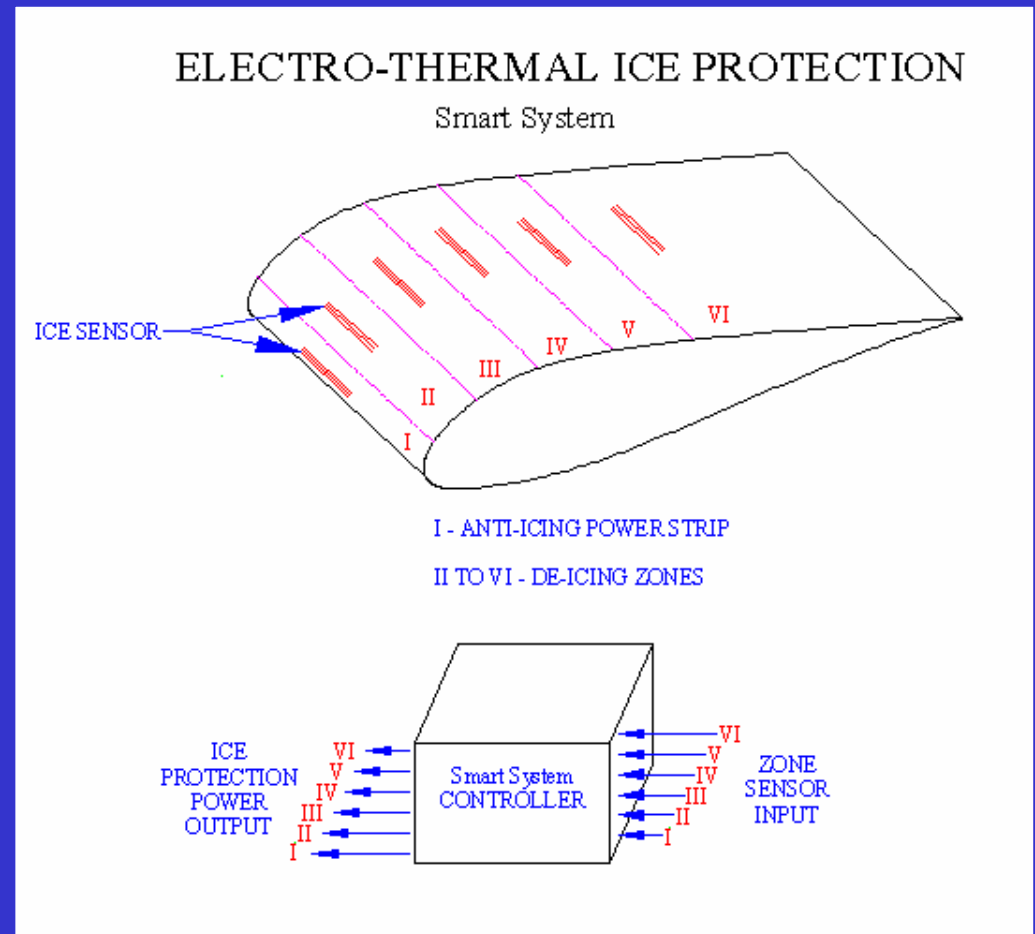
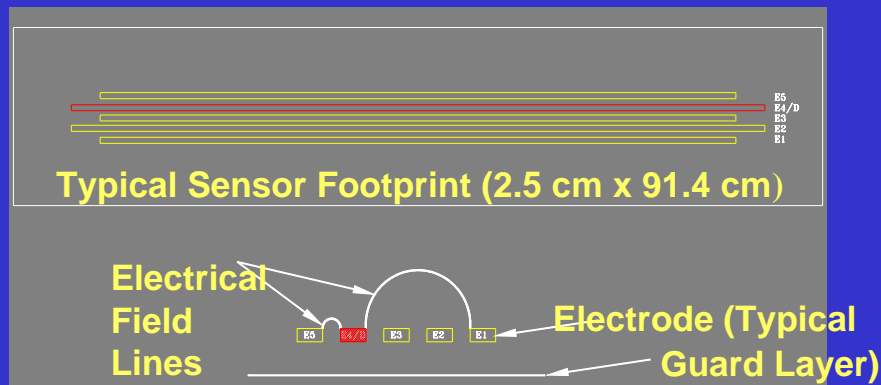
- HUMS System Allow Systems to be Maintained “On Condition”
 - Change Maintenance Behavior from Time to On Condition
 - Allows “Opportunistic” Maintenance
 - Do Maintenance/Inspection When Convenient
 - Damage Accrues Slowly Over Life of Components
 - Monitoring Allows Detection of Degraded Components
 - Gives Guidance On When to Perform Maintenance/Inspection
 - Reduces Operating Cost By:
 - Reducing Unnecessary Maintenance Calls
 - Targets Maintenance Action

Low Power Electrothermal Ice Protection

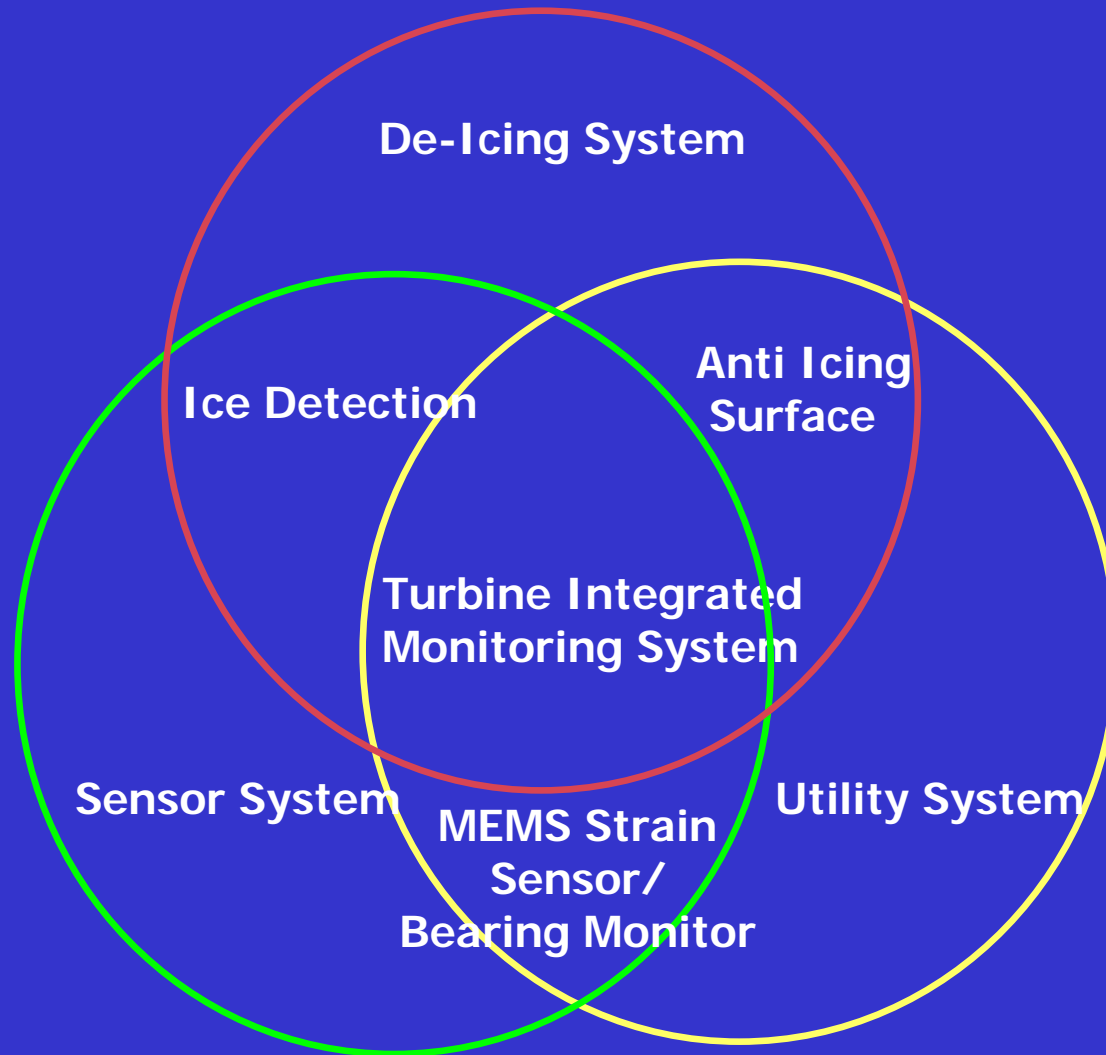
Key Benefits:

- Low Power 75-90% Power Savings from Conventional Electrothermal System
- Self-Monitoring Capability

Sensor Layout



Goodrich Technology Integration



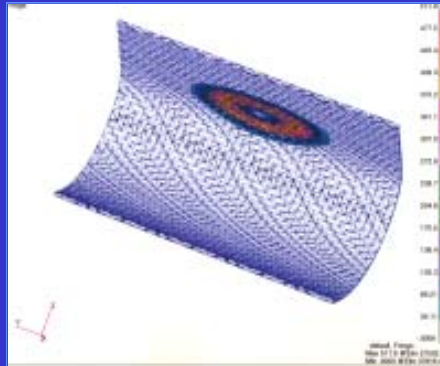
DSS Capabilities

Simulation Capability

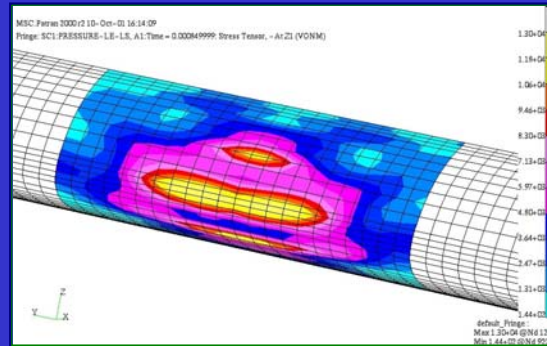
NASA - LEWICE



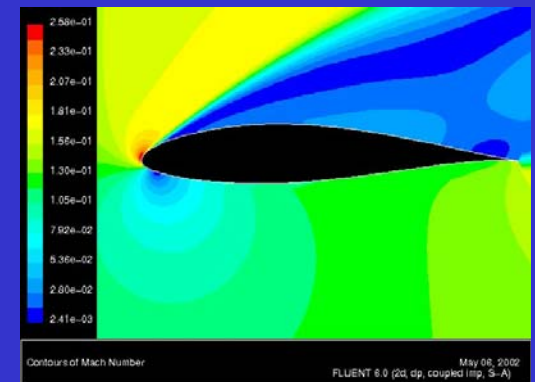
ELECTROMAGNETIC



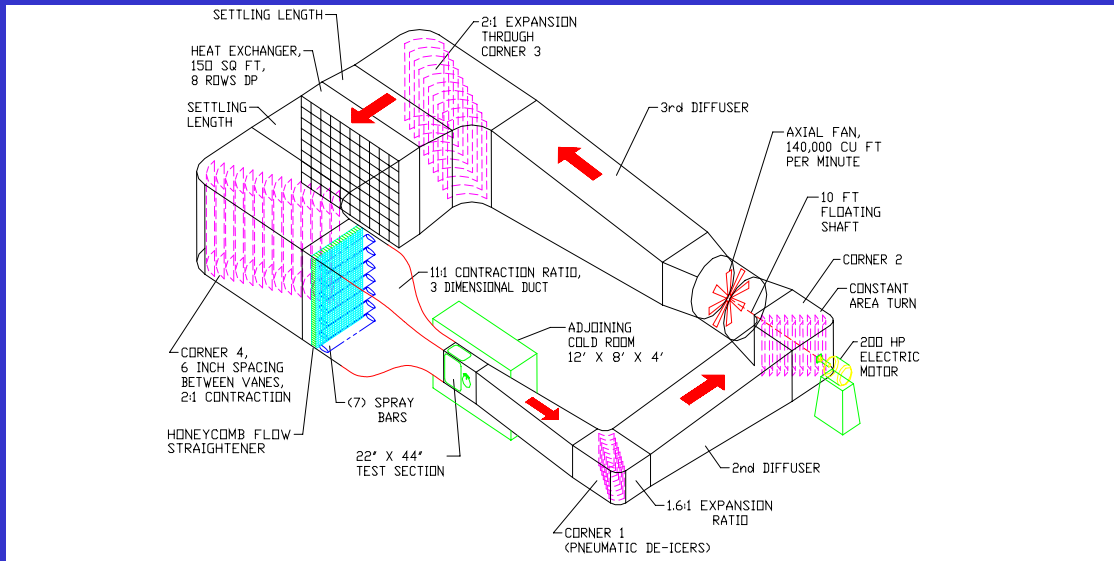
NASTRAN



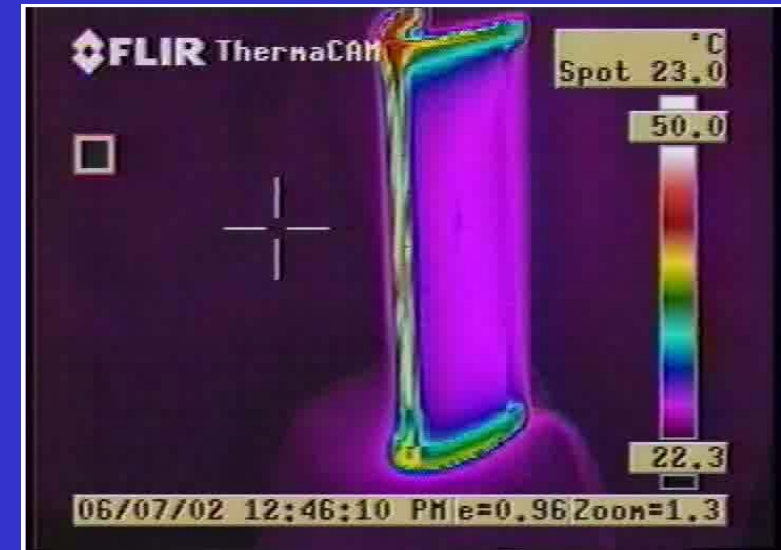
CFD - FLUENT



Test Capability



ICING RESEARCH TUNNEL



THERMAL IMAGE

SSD Capabilities

- **Extensive Experience In the Development of Strain Sensors and Signal Conditioning Software**
- **Technological Considerations:**
 - Corrosion Detection
 - Fiber Fabry-Perot
 - Fiber Bragg Grating
 - Metal Foil Gages
 - Semiconductor Gages
 - Fiber Optic Gages
 - Acoustic Emission – Piezoelectric
 - Tagging
 - AE* – Fiber optic
 - Induction
 - Dielectric
 - Magnetic Strain
 - Trip Wire
 - Tagging

FUS Capabilities

- **8 Years of HUMS Integration on Helicopter**
- **Extensive Experience In System Design/Application Integration**
 - Exceedance Monitoring
 - Cycle Counting
 - Advance Signal Processing for Fault Detection in Bearings/Shafts/Gears
- **Large Fleet of IMD HUMS Equipped Aircraft**
 - OEM on Sikorsky S-92
 - UH-60L
 - CH-53E
 - SH-60B
 - AH-1

HOW DO WE DO IT ?

- **Technology Transfer / Adaptation**
- **Development Partner**
- **Will To Make It Happen**

Contact:

Ken Fisher

Goodrich Corporation

Business Development

(330) 374-3706

ken.fisher@goodrich.com